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DESIGN AND IMPLEMENTATION OF AN ARCHITECTURE FOR A REMOTELY OPERATED PLC LABORATORY USING LABVIEW

JAGADEESH R[1], R. RANGANATHA[2] & C. SIDDARAJU[3]

[1,2]*Department. of Mechanical Engineering, S. J. C. Institute of Technology, Chickballapur, India*

[3]*Department. of Mechanical Engineering, M. S. R. Institute of Technology, Bangalore, India*

ABSTRACT

In India, imparting practical knowledge about industrial automation to engineering students is still in its infancy. Technical facilities are available only at a few engineering colleges. As a result, it is necessary to share these facilities. One efficient way of doing this is through a remotely operated laboratory, where equipment related to automation, such as a PLC, can be used from distant places.

This paper describes a LabVIEW based approach for remote operation of a Programmable Logical Controller (PLC). A client - server architecture was built using LabVIEW technologies, such as Data Socket and Network Variables, Web Service, and Remote Panels, to access and program the PLC through internet. A LabVIEW VI was created to provide virtual HMI for PLC operation. Various function blocks were developed to execute PLC operations. In addition, a report function was included to automatically document the experiments.

KEYWORDS: Programmable Logical Controller (PLC), Remote Laboratory, Labview, Industrial Automation & Industrial Internet of Things.

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Original Article

1. INTRODUCTION

Automation is the application of various technologies to develop a system or sequence of events that executes on its own. Presently, automation can be found in various fields of engineering. A key advantage of automation is repetition of tasks with high throughput and efficiency.

The integral component of any automated system is a Programmable Logical Controller (PLC). PLCs are specifically designed to operate in an industrial environment. Typical inputs are push buttons, switches, and sensors. Typical outputs are coils, lamps and solenoids.

At SJCIT, PLC utilized for trainings is the IndraLogic L10. It is a modular PLC perfectly suitable for learning purposes. It has 8 onboard digital inputs and four digital outputs. In addition, inline modules provide 16 more digital I-Os and 2 analog I-Os.

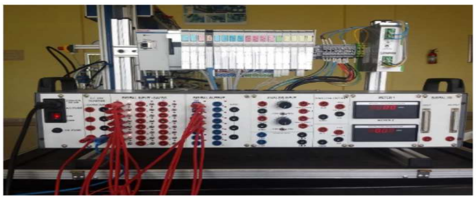

Figure 1: Snapshot Showing Indra Logic L10 PLC and I-O Adapter

2. LITERATURE SURVEY

In the present paper, effort is made to design, implement and evaluate a remote Programmable Logic Controller laboratory for various applications. Presently the internet is extensively used as a connectivity tool for various purposes. From the survey of literature, it has been observed that, few attempts are made to remotely operate the PLC based laboratory using different methodologies. The following section briefs such methodologies used by various researchers.

Jamal and Wenzel [1] explain the use of LabVIEW in real world applications. In the paper authors provide in depth history of LabVIEW programming language and its evolution since its creation. In addition, various programming features of LabVIEW are also presented.

Choi et al. [2] have created a web based system for a shipyard facility control and monitoring. The aim of their work was to develop a remote system to monitor gas and boiler utility management. The biggest challenge in their work was handling the outdated controller, which couldn’t be connected directly to the internet. The authors interfaced the old systems with an industrial PLC for the handling of the system and communication.

Naghedolfeizi et al. [3] introduce a number of technologies available in LabVIEW for online experimentation. In this paper, the authors recognize the importance of internet and web enabled industrial applications. The available technologies have been split into a web and internet based. Web based are the ones that allow applications to be controlled through an internet browser.

Bauer and Ionel [4] have developed a distant solar lab using Web Service and Web Publishing Tool. In this work, a distant photovoltaic module is operated through remote panels and Web Service to obtain maximum power peaks. Aim is to learn about energy conservation under varying conditions, tracking power peaks and deployment of Dynamic Link Library (DLL).

Wei et al. [5] Have developed a mobile robot that can be controlled through the internet. The wheeled robot is built using a NI real time controller that connects wirelessly to the internet to receive and transmit information. In addition, a CCD camera provides a live stream from the robot POV. The main task of the real time controller is to control the two voltage supply to the two wheels in order to vary the speed.

3. LABVIEW ARCHITECTURE FOR REMOTE PLC

The architecture consists of three sections: Client, Server and PLC. The server PC is physically connected to the PLC. This computer configures the PLC, publishes relevant data and manages requests from clients. The client is the final user, who seeks control of the PLC to execute an application. Based on the client’s request, the control is handed over them for either remote programming, control or monitoring.

The L10 PLC is connected to the server computer with an Ethernet cable. The PLC is configured with the software IndraWorks Engineering. With IndraWorks, communication is established between PC and PLC, the necessary input/ output (I/O) modules are selected and the necessary I/Os are declared. If the I/Os are declared as Global Variables, they are published to the IndraWorks Secure Copy Protocol (IwSCP) server. Operation of the server is very similar to the OPC server. IwSCP enables the connection of IndraWorks, in turn PLC, with other software installed on the Windows operating system.

Indra Works is connected with LabVIEW through IwSCP server. The various I/Os declared in IndraWorks can be

imported to the LabVIEW environment for programming. LabVIEW allows program creation, as well as, HMI development. The HMI/ user interface is created in what is known as the "Front Panel" and the programming is carried out in the "Block/ Back Panel".

Once the LabVIEW program (VI) has been developed, various in-built technologies can be used to deploy the program to the internet/ world wide web. The selection of different deployment technique depends on the type of application. For simple monitoring, web services can be used. For control and monitoring, web publishing and network variables are essential. Finally, for remote program development, Network shared Variables and Data Socket are utilized.

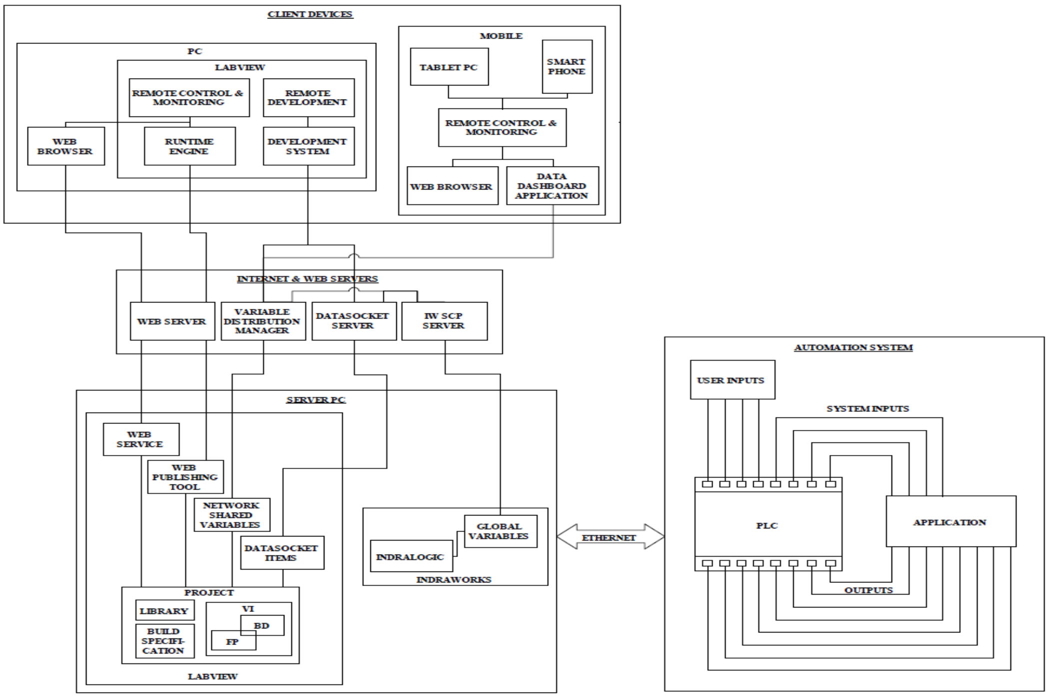

Figure 2: Block Diagram of Remote PLC Architecture

4. IMPLEMENTATION

A. PLC Inputs - Outputs Deployment

Since the PLC will be operated remotely, it should be ensured that every I-O has remote access. For the deployment of I-Os, the methodology explained in the previous section are followed. Every PLC I-O is declared as a global variable and uploaded to the IwSCP Server. These I-Os are imported to the LabVIEW development system for programming. After importing it to LabVIEW, these variables are published to the network so that are accessed remotely. LabVIEW Network Variables and Data Socket technology is used for I-O transmission.

B. LabVIEW Interface

The LabVIEWVI, contains a virtual HMI for control and programming of the PLC. The HMI is as shown in Figure 3. Here, the users will have access to all of the PLC digital and analog I-Os that will be needed for programming. In addition, to aid the programming process certain provisions have been provided, such as, custom library, graphical charts, report generation and chat function.

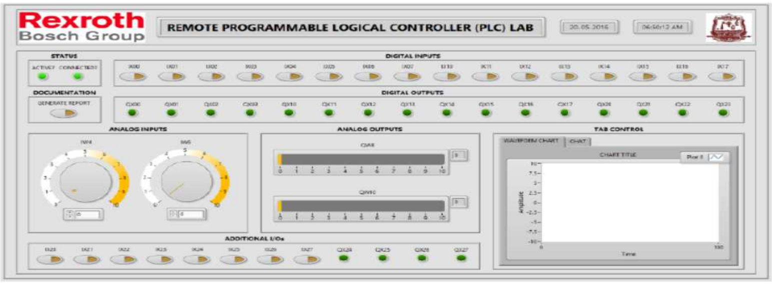

Figure 3: Screenshot Showing the Labview HMI for L10 PLC

Apart from the I-Os, most often used elements in PLC programming are function blocks, such as, timers, triggers and counters. However, these blocks are not available in the LabVIEW base system. In order to provide these functions, custom blocks have been built. The VI for a pulse timer is as shown below.

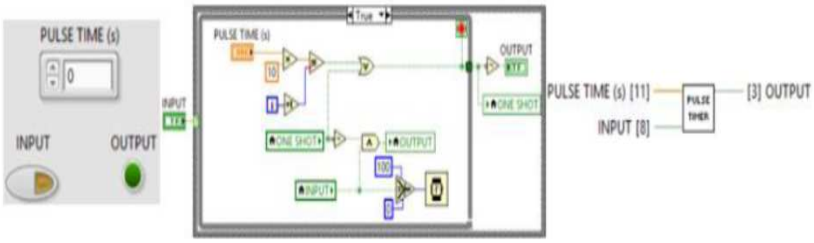

Figure 4: Screenshot Showing the VI for Pulse Timer

SubVIs are created to obtain a modular function blocks that can be used during programming. A host of these function blocks has been accumulated to create a custom library that can be easily distributed. Figure 5 shows the customized library, once installed, they can be accessed in the block panel of LabVIEW.

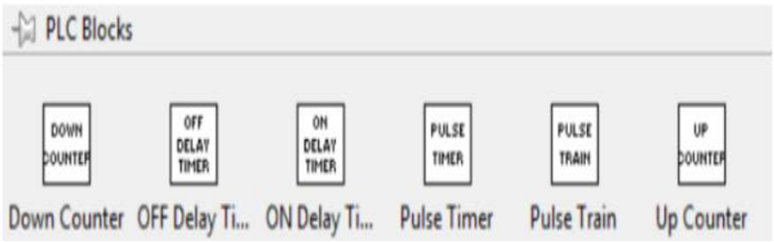

Figure 5: PLC Function Blocks

One of the advantages of working in a physical lab is constant interaction with other trainees and trainers. However, in a remote lab, the participants will be at distant places. Hence, to facilitate communication between them, a chat function is available in the main VI. This function can be used by trainees and trainers to communicate with each other.

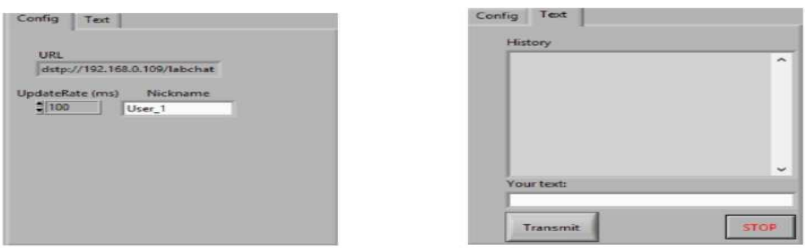

Figure 6: Screenshot Showing the Front Panel of Remote Lab Chat

The final feature, that is available in the remote PLC VI is automatic report generation. In the block panel "Generate Report" function is used (Figure 7). This block generates a user specified report to document the experiments. It provides data regarding the experiment, the front & block panel, graphs and charts. The biggest advantage of this feature is time saving. Trainees can instantly document of their experiments.

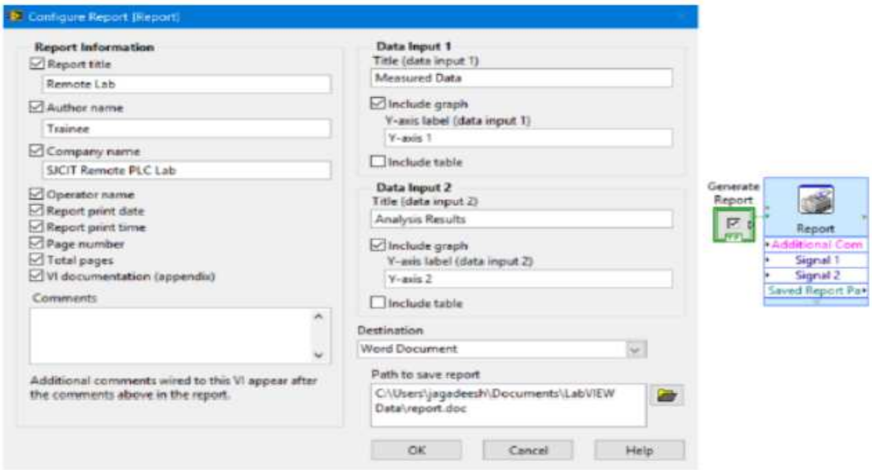

Figure 7: Screenshot Showing the Configuration for Report Generation

C. Distribution

All of the features mentioned above are contained in a LabVIEW project. This file has to be distributed the trainees who need to access the lab. The best way to the distribute the file is through LabVIEW "Build Specifications" (Figure 8). It allows the creation of an installation file that can be easily distribute to the trainees. The installation file build process and generated files are as shown below.

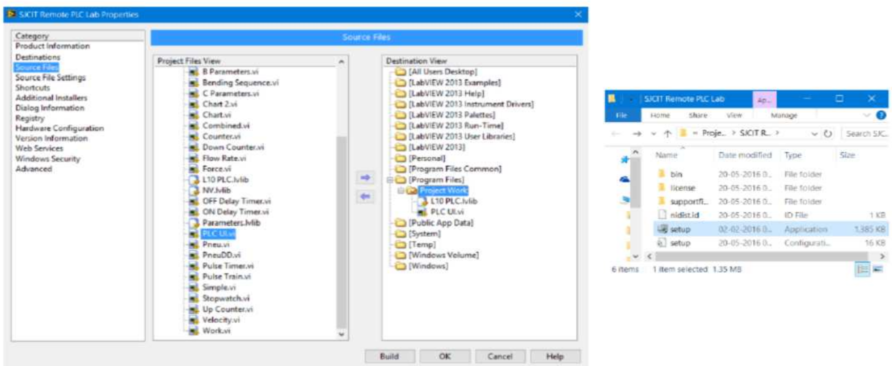

Figure 8: Screenshot Showing the Files Selected for Installer Creation

4. RESULTS

The trainees accessing the SJCIT Remote PLC Lab have to first run the installer file on their PC (Figure 9). This will create the Remote PLC Lab VI on the users' system, which will contain the features mentioned in the previous section. Once the installation completes, users, can access the PLC through the VI as if the PLC is available locally.

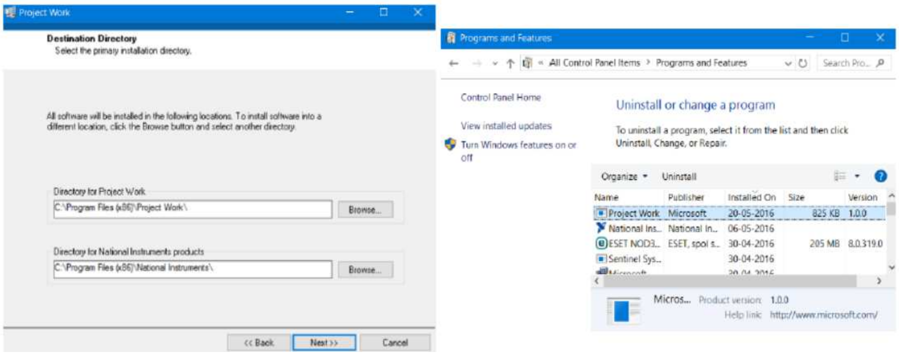

Figure 9: Screenshot Showing the Installation of Remote Lab VI

Since most of the work will be done on the users' PCs, the task of the server is only to enable the connectivity of remote devices to the PLC. This is done by deploying network shared variables to the network (Figure 10).

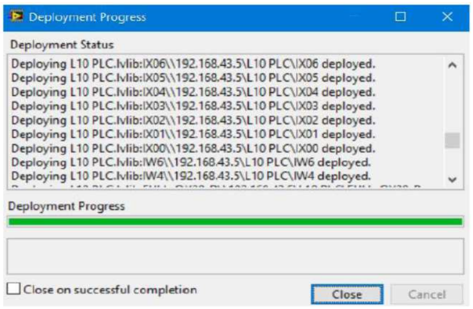

Figure 10: Screenshot Showing the Deployment of PLC Variables

Once this is done, the work of the server is complete and the control of the PLC will be handed to the remote users. The remote users can find the networked PLC variables in the distribution manager, under the server IP address (Figure 11). The users need not select any variables from this list, as all of the PLC variables are available in the installed VI. In addition to the available I-Os, users can also use virtual instruments available in LabVIEW.

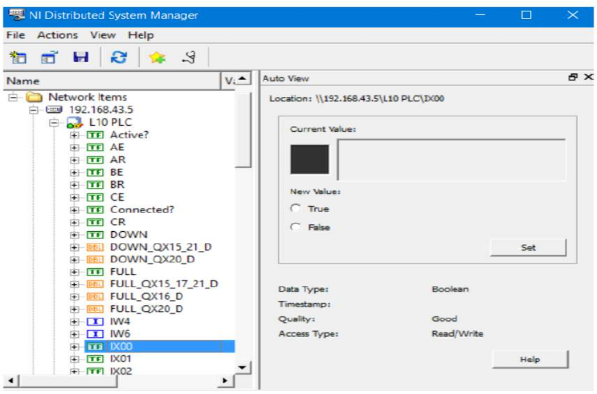

Figure 11: Screenshot Showing the Variables Available at the Server IP Address

An example of remotely developed VI can be seen in Figure 12. Here, the VI sequentially turn ON Boolean outputs based on analog input values. The output IX00 turns ON, when input is between 0 and 3; outputs IX00 and IX01 turn ON when inputs is between 4 & 7. Finally, all outputs, IX00, IX01 and IX02 turn ON, when input is between 8 &10.

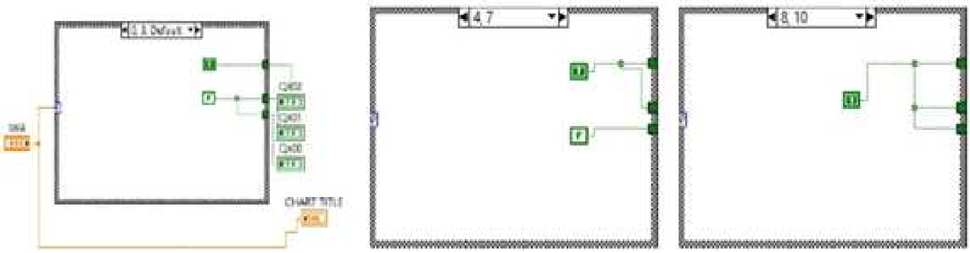

Figure 12: Screenshot Showing Case Structures of the VI

After executing the VI, trainees can utilize any of the deployment methods explained in the previous section to distribute their VIs. For example, trainees can use the chat function to notify the trainer that they have completed a particular program and it provides a link for its remote access (Figure 13).

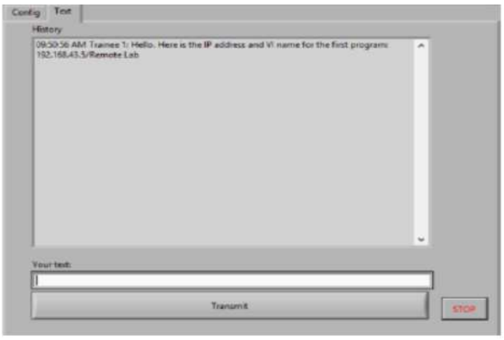

Figure 13: Screenshot Showing the Chat Notification for a Deployed VI

The trainers can use the link to launch the VI on their PC to control and monitor the VI. In addition, they can also use remote debugging to verify the program. After examining the program, they can provide feedbacks to the trainees.

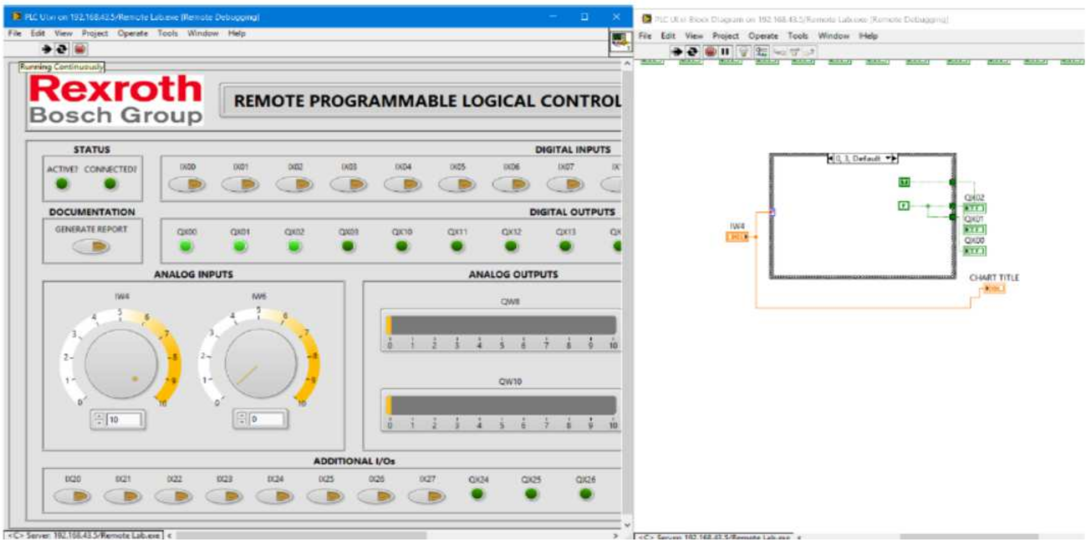

Figure 14: Screenshot Showing Remote Debugging of a VI

Once the execution and debugging of the VI is done, the trainees can conclude the experiment by generating the report. Trainees can use the Generate Report function to build the report. They have the choice of building the report in the required format, such as, word, Excel or HTML.

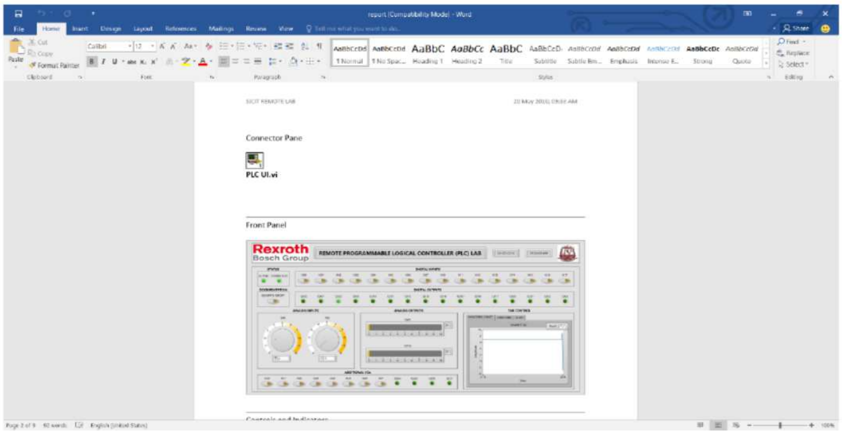

Figure 15: Screenshot Showing the MS – Office Report Generated for the Experiment

5. CONCLUSIONS

The Client – Server architecture for PLC based Automation was successfully developed and implemented. The architecture enabled integration of automation with Internet and Web technology. As a result of this the PLC could be remotely programmed and operated. The LabVIEW VI allowed easy creation and deployment of PLC programs. The chat feature ensured constant communication between various users. Finally, the report generation function allowed users to document their PLC experiments.

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